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# Learning about compliance under asymmetric information

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### ABSTRACT

Over time, inspection agencies gather information about firms' pollution levels and this information may allow agencies to differentiate their monitoring strategies in the future. If a firm is less successful than its peers in reducing emissions, it faces the risk of being targeted for increased inspections in the next period. This risk of stricter monitoring might induce high-abatement cost firms to mimic low-abatement cost firms by choosing lower emission levels, while the latter might try to avoid being mimicked. We explain firms' compliance decisions and the inspection agency's monitoring strategy by means of a signaling game which incorporates dynamic enforcement and learning. Interestingly, we show that the ongoing signaling game between firm types might lead to firms over-complying with the emission standard.

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## 1. Introduction

Firms' compliance status with environmental rules is sometimes affected by that of other firms. For example, in the US pulp and paper, chemical or petroleum industries, there exists empirical evidence that the compliance status of one firm positively depends on the compliance record by *rival* firms located in the same state (see Decker and Pope, 2005). This suggests that pollution reductions by one firm influence further pollution reductions by other firms, so that compliance decisions might be seen as *strategic complements*. Decker and Pope (2005)'s explanation for this phenomenon relies on the fact

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that increased compliance by one firm reduces enforcement resources allocated to that firm and increases resources allocated to its rivals, thus increasing rivals' compliance rates.

The purpose of this paper is to provide an alternative explanation for this empirical observation. Decker and Pope (2005) consider a static setting and explicitly model the enforcement part of the regulation. We instead concentrate on the dynamic influence of firms' past compliance status on future regulations. The reason is that a lot of empirical evidence exists to support the fact that inspection agencies impose more stringent enforcement policies on those firms polluting more. For example, Nadeau (1997) finds for the US pulp and paper industry that both the probability of inspection and the probability of enforcement actions depend positively on the potential amount of emissions; for the US chemical and pulp and paper industries Decker (2005) shows that plants which produce less TRI chemical releases per unit production are less likely to be inspected than plants which produce large TRI chemical releases; Gray and Deily (1996) find for the US steel industry that regulatory actions depend on tons of emissions produced; Eckert (2004) shows for petroleum storage sites in Canada that inspections depend on the number of tanks at an installation; Rousseau (2007) shows for the Belgian textile industry that inspections depend on the potential amount of emissions, proxied by the firm's capacity; Stafford (2002) finds for the US hazardous waste regulations that inspections depend on the (log of) tons of waste generated; among others.

Since inspection agencies and polluting firms interact overtime, the former collect information on firms' types by performing audits and measuring emission levels. Since enforcement resources are scarce, the monitoring strategy in subsequent periods is then determined not only by the firms' past compliance status, but also by their performance *relative* to the other firms. This acts as a *signal* of the firms' types, since a firm that is less successful in reducing pollution faces the risk of being targeted for increased inspections in the next period.

The interaction between firms' relative emission levels and future inspections implies an interesting signaling game. Forward looking firms with higher abatement costs might be tempted to choose sufficiently low levels of emissions (i.e., mimic low-cost firms) in order to face laxer enforcement in the next period. But, at the same time, low-cost firms might try to prevent being mimicked by high-cost firms in order to be treated as a group with enforcement privileges. As a result, actual emissions might be considerably lower than those expected in a static (or one-period) regulatory process. In fact, this process may even lead firms to do better than legally required, i.e. they might over-comply with the regulation in place.<sup>1</sup>

Our signaling game results in three possible equilibrium outcomes: (i) a separating equilibrium where the threat of mimicking is absent; (ii) a separating equilibrium where low-cost firms actively prevent being mimicked by high-cost firms; and (iii) a pooling equilibrium where all firms choose the lowest possible emission level, in the spirit of Kreps and Sobel (1994). A separating equilibrium (in either case (i) or (ii)) allows the inspection agency to learn the type of additional firms and use the acquired information in the following regulatory period.

Interestingly, we show that the agency is able to induce each specific type of equilibrium by adapting its inspection strategy. The agency trades off two counteracting effects. Firstly, it can use the information previously obtained and focus on firms it knows will generate high returns in the current period. Or secondly, it can try to gather information on unknown firms and thus increase future payoffs. A separating equilibrium is shown to be more likely under a low inspection probability. After all, the smaller the inspection probability, the smaller the expected gain a high-cost firm can get from pretending to be of the low-cost type. Similarly, increasing the inspection probability ultimately makes the incentive of the high-cost firms to imitate the low-cost type so strong that low-cost firms cannot do anything to avoid it and a pooling equilibrium ensues.

We assume that agency's decisions are based on concerns with regulatory compliance as well as (to various extents) on the level of the associated firms' abatement costs (see also Harford and Harrington, 1991 or Keeler, 1995). A nice implication of our study is that governments can use monitoring budgets to correct agencies' strategies when agencies' objectives depart from the strict social cost viewpoint.

<sup>1</sup> Among others, Arora and Gangopadhyay (1995), Maxwell et al. (2000), Bagnoli and Watts (2003), Lyon and Maxwell (2003, 2004), Shimshack and Ward (2008) and Wu and Wirkkala (2009) have provided alternative reasons of over-compliance with existing regulations.

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